SPACE LAUNCH SYSTEM PAYLOAD TRANSPORTATION BEYOND LEO. S. D. Creech[1], J. D. Baker[2], A. L. Jackman[3] and G. Vane[4], [1]NASA/MSFC Huntsville, AL 35812, steve.creech@nasa.gov, [2]Jet Propulsion Laboratory, Pasadena, CA 91109, john.d.baker@jpl.nasa.gov, [3]NASA/MSFC Huntsville, AL 35812, angie.jackman@nasa.gov, and [4]Jet Propulsion Laboratory, Pasadena, CA 91109, gregg.vane@jpl.nasa.gov

Introduction: NASA has successfully completed the Critical Design Review (CDR) of the heavy lift Space Launch System (SLS) and is working towards the first flight of the vehicle in 2018. SLS will begin flying crewed missions with an Orion capsule to the lunar vicinity every year after the first 2 flights starting in the early 2020's. As early as 2021, in addition to delivering an Orion capsule to a cislunar destination, SLS will also deliver ancillary payload, termed "Co-manifested Payload (CPL)", with a mass of at least 5.5 mT and volume up to 280 m^3 simultaneously to that same destination. Later SLS flights have a goal of delivering as much as 10 mT of CPL to cislunar destinations.

In addition to cislunar destinations, SLS flights may deliver non-crewed, science-driven missions with Primary Payload (PPL) to more distant destinations. SLS PPL missions will utilize a unique payload fairing offering payload volume (ranging from 320 m^3 to 540 m^3) that greatly exceeds the largest existing Expendable Launch Vehicle (ELV) fairing available. The Characteristic Energy (C3) offered by the SLS system will generate opportunities to deliver up to 40 mT to cislunar space, and deliver double PPL mass or decrease flight time by half for some outer planet destinations when compared to existing capabilities. For example, SLS flights may deliver the Europa Clipper to a Jovian destination in under 3 years by the mid 2020's, compared to the 7+ years cruise time required for current launch capabilities.

This presentation will describe ground and flight accommodations, interfaces, resources, and performance planned to be made available to potential CPL and PPL science users of SLS. In addition, this presentation should promote a dialogue between vehicle developers, potential payload users, and funding sources in order to most efficiently evolve required SLS capabilities to meet diverse payload needs as they are identified over the next 35 years and beyond.

National Aeronautics and Space Administration

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SPACE LAUNCH SYSTEM

SLS Payload Transportation Beyond LEO

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1 March 2017

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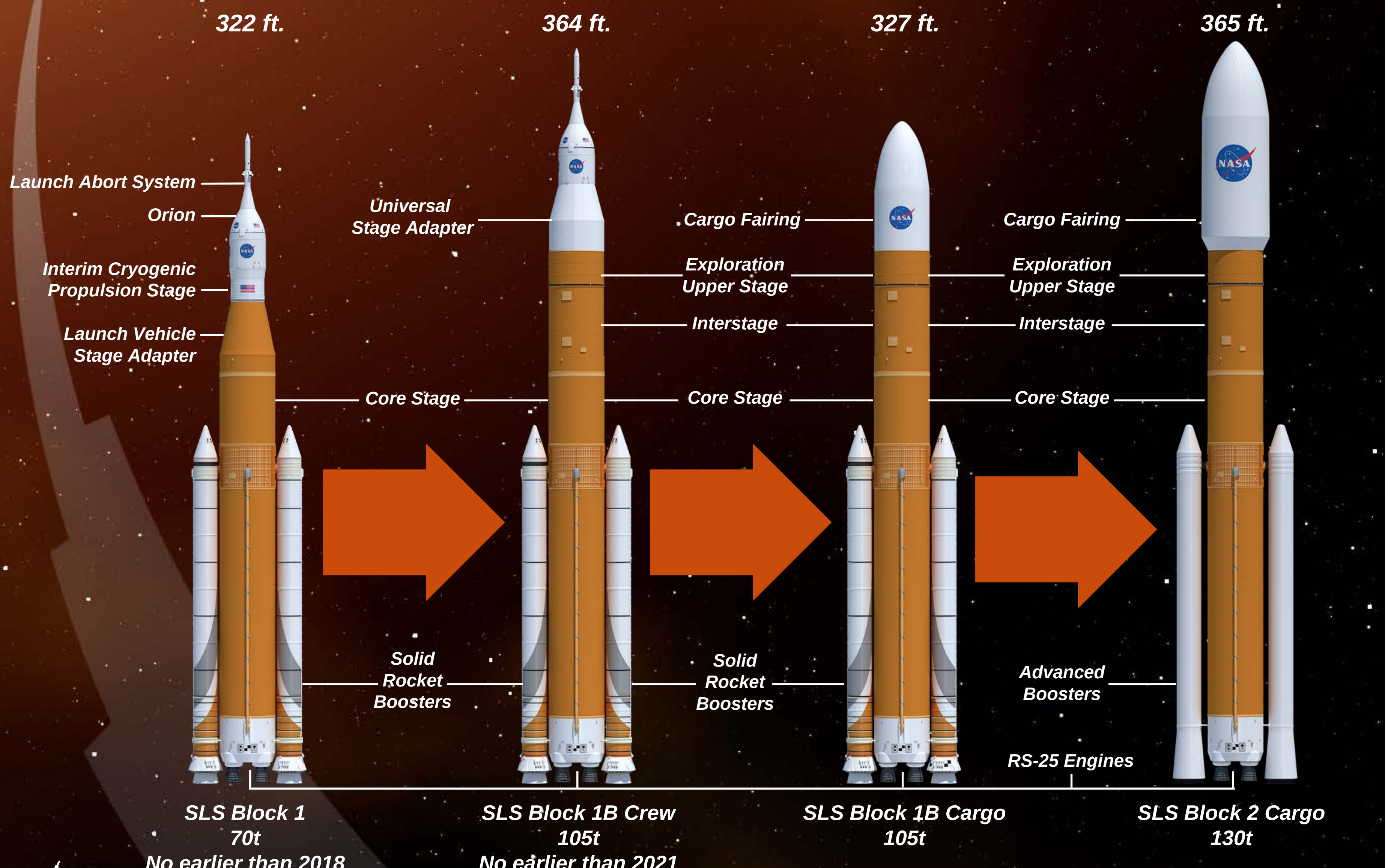
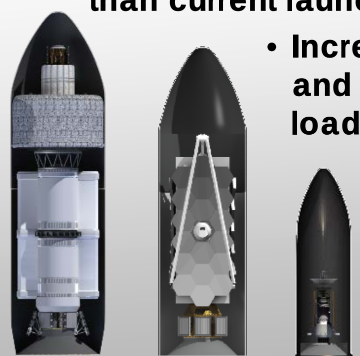
SLS Evolution Overview



Benefits of SLS Performance

Increased Mass/Volume Payload to Orbit

- **Up to 5 times greater mass to orbit capability than current launch systems**
- **Increases payload mass margins and offers greater propellant loads**
- **Accommodates a range of (5m-10m) fairing sizes**
- **Up to 6 times greater payload volume**

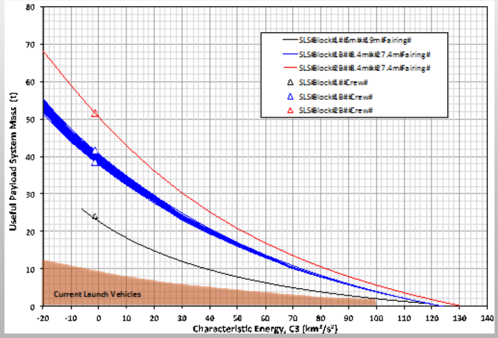


10m 8.4m 5m

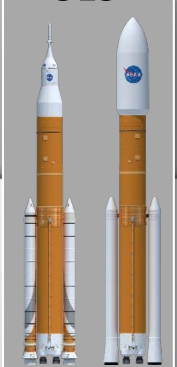
Range of Concepts

Larger Interplanetary Mass to Destination

- **3 to 4 times the mass to destination**
- **Single launch of larger payload reduces payload complexity**
  - Human Cis-lunar
  - Human Mars
  - Asteroid Redirect Mission
  - Mars Sample Return
  - Jupiter Europa Orbiter
  - Saturn/Titan Sample Return
  - Ice Giant Exploration
  - Outer Planet Sample Return
  - Large Telescopes



SLS



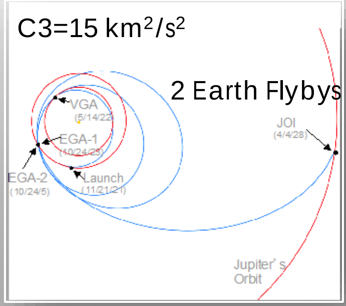
105t Blk 1B

130t Blk 2

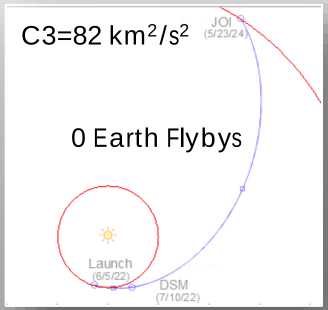
Shorter Transit Times to Destination

- **Jovian system transit time reduced up to 70%**
- **Longer launch window provides more mission margin**
- **Reduced mission operations cost over time**

With fly-bys, 6.4 years

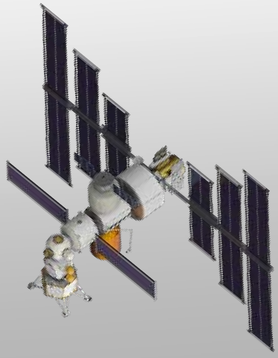


SLS Direct, 1.9 years

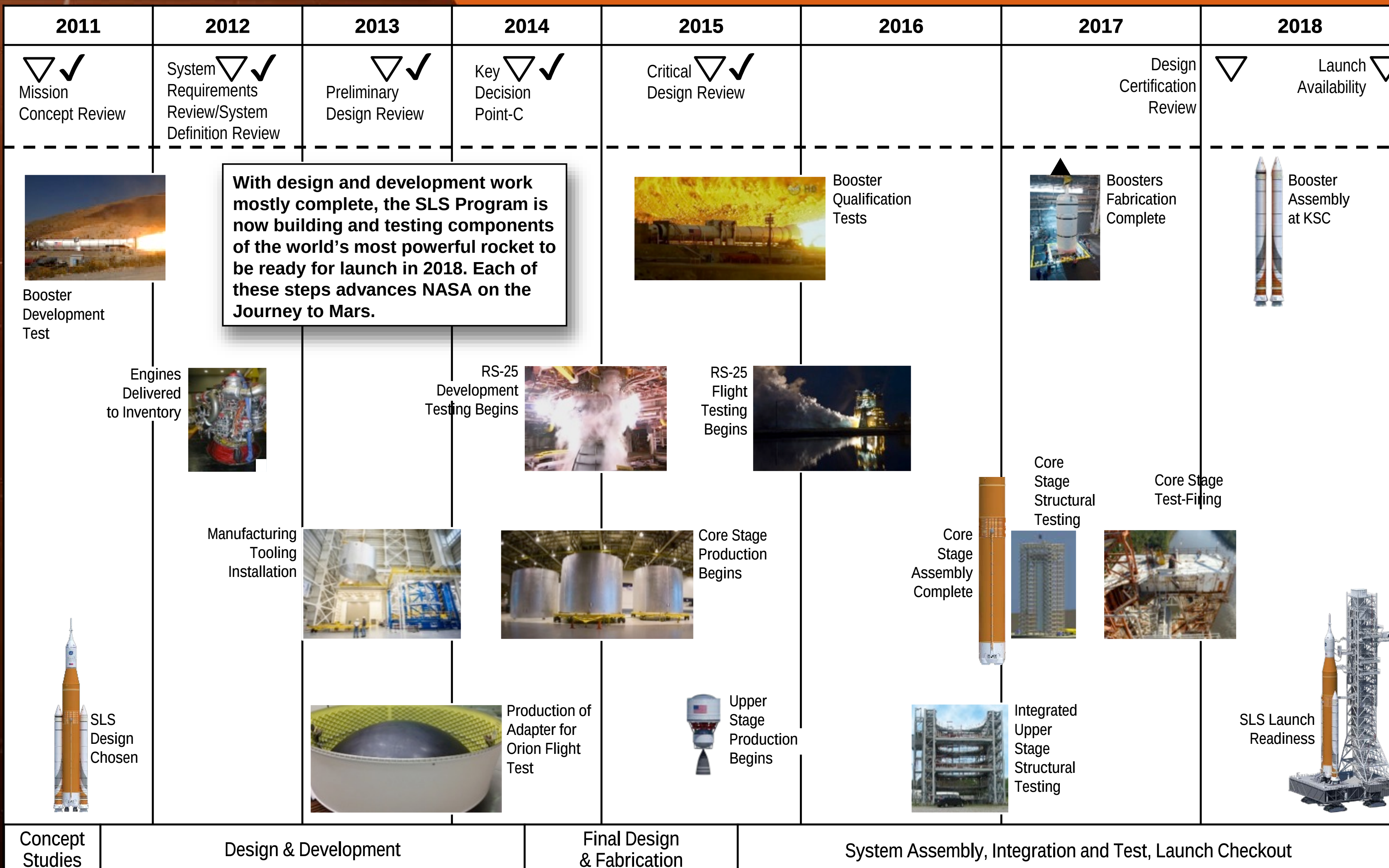


Enhanced Reliability and Safety

- **Fewer deployments simplifies orbital operations (less orbital assembly for large spacecraft)**
- **Significantly less time in Earth Orbit reduces propellant boil-off**
- **Reduces need for Earth flyby minimizing nuclear safety concern**



Space Launch System Path to the Pad



SLS

www.nasa.gov/sls

Recent Progress Toward Launch

Core Stage production at Michoud

Booster testing at Orbital ATK

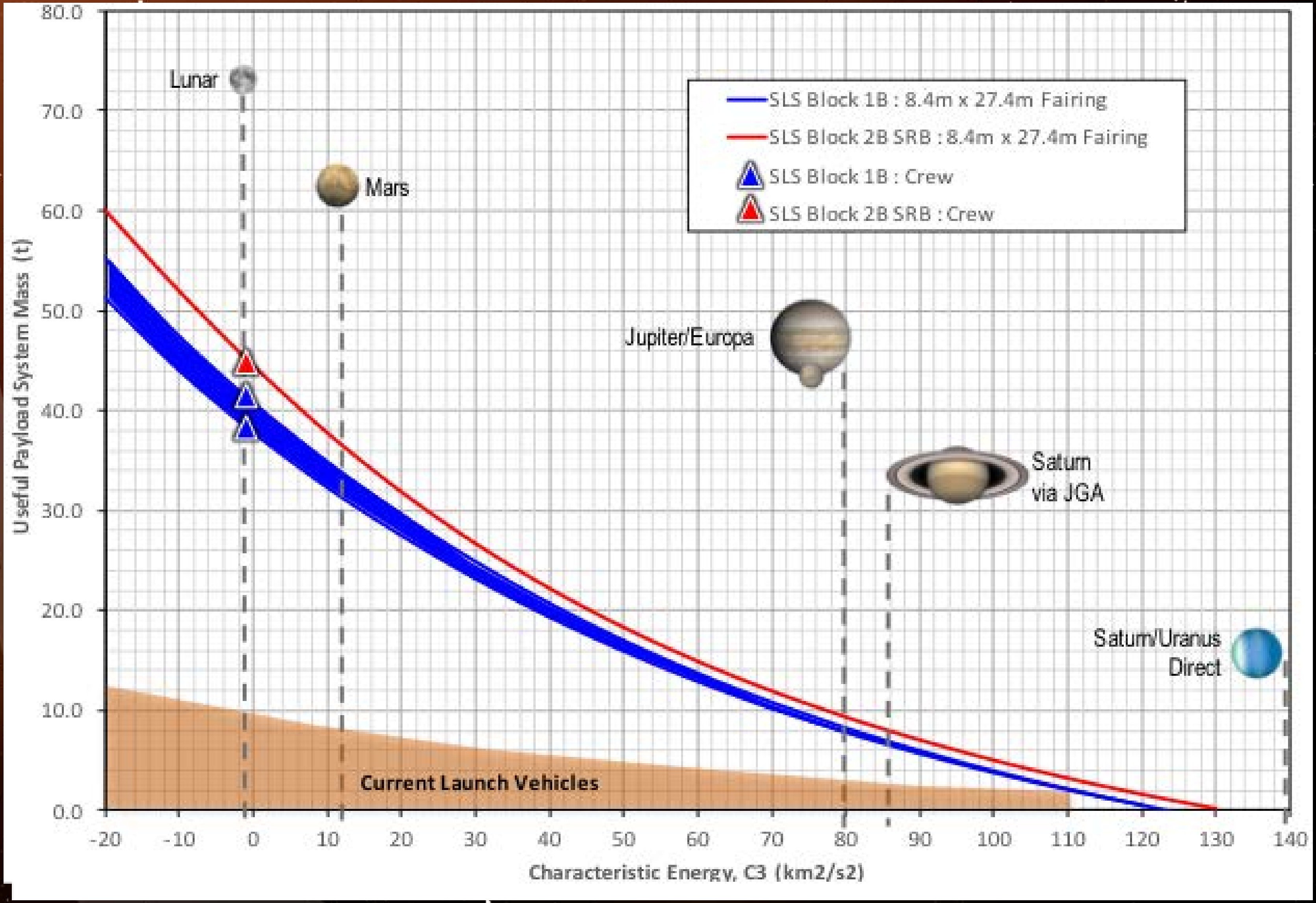
Engine testing at Stennis Space Center

Test stand construction at Marshall

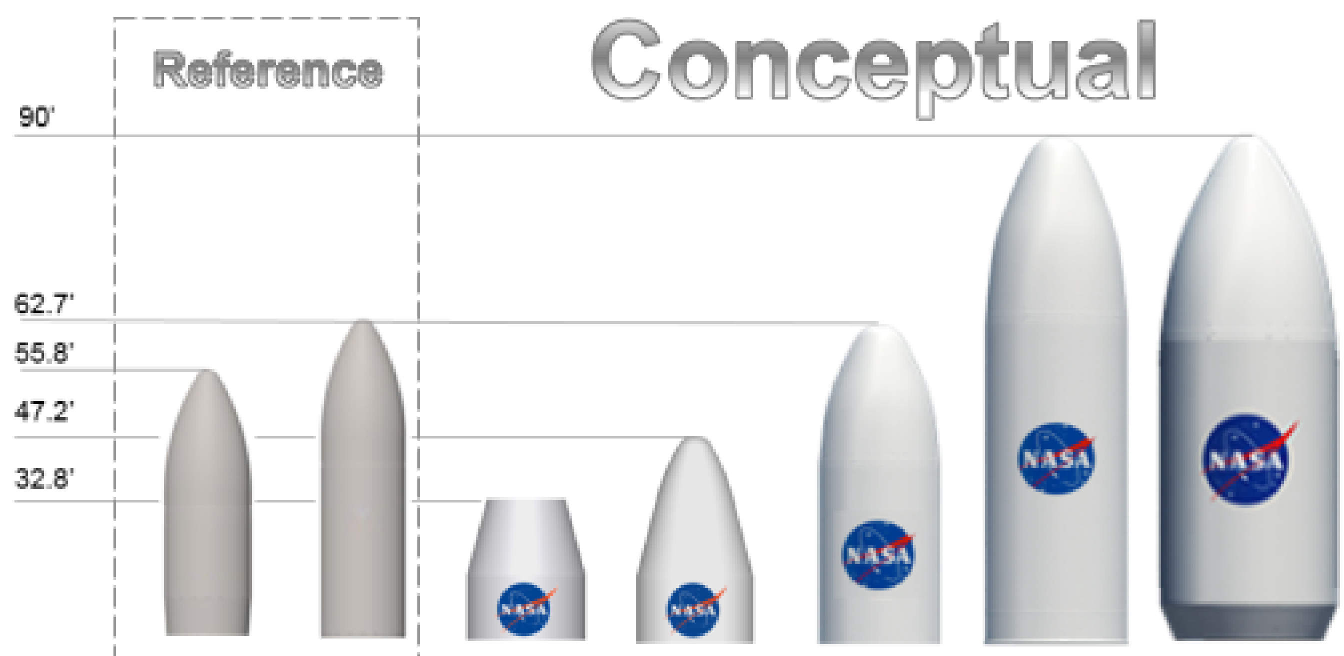
Stage adapter welding at Marshall

Upper stage production at ULA

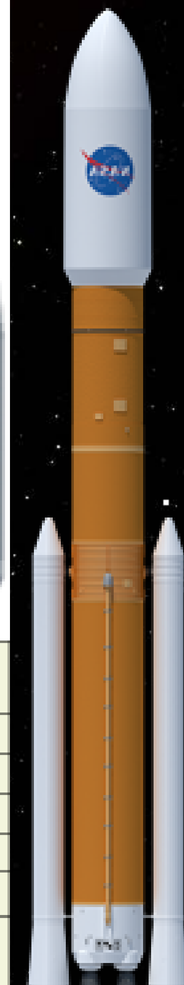
SLS Payload Mission Capture



Range of Payload Encapsulation



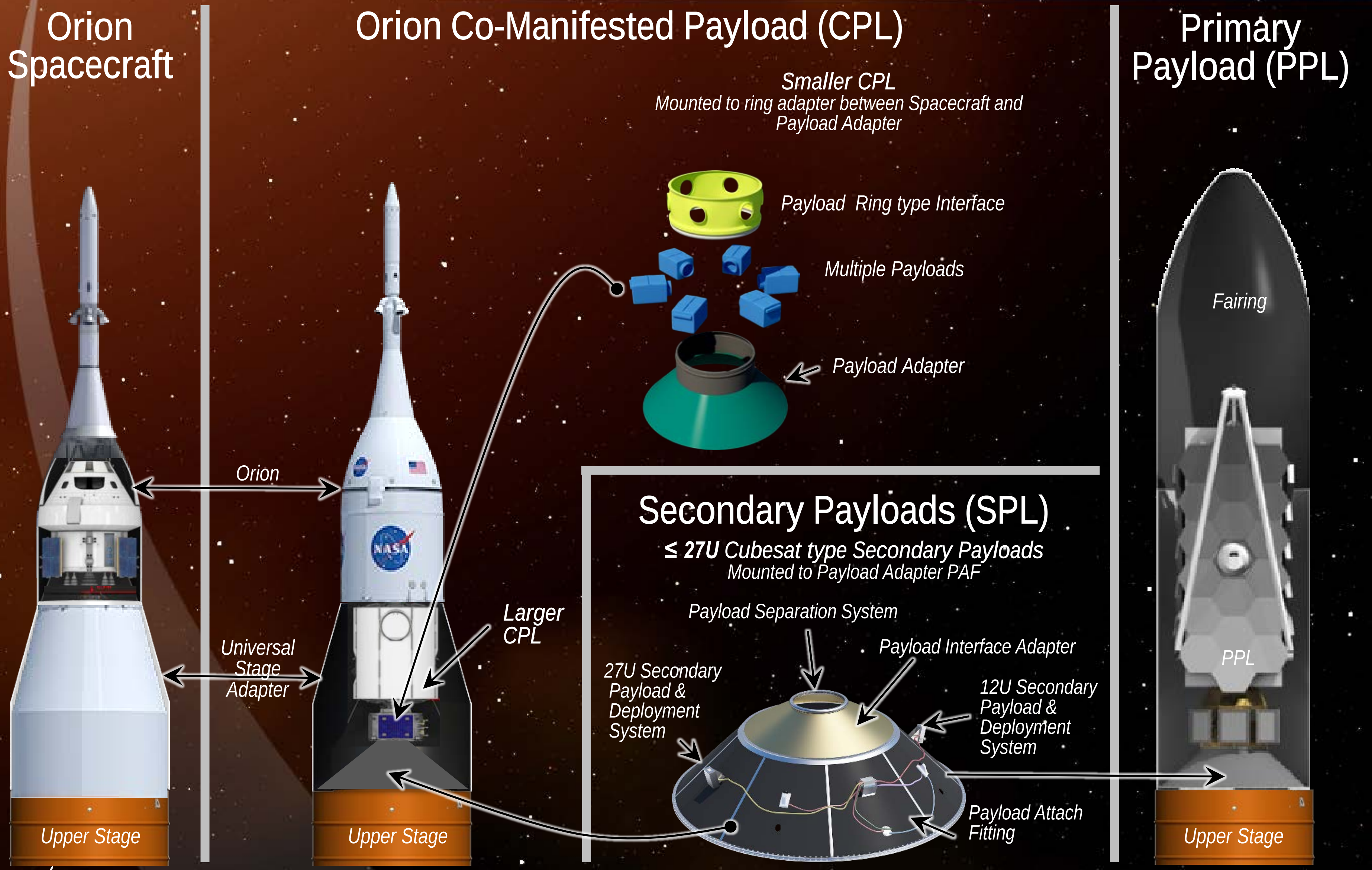
Payload Accommodation	5.4m	5.1m	USA2	USA4	8.4m Short	8.4m Long	10m
Type	5m COTS	5m COTS	8.4m CPL	8.4m PLF	8.4m PLF	8.4m PLF	10m PLF
Length	55.8 ft	62.7 ft	32.8 ft	47.2 ft	62.7 ft	90 ft	90 ft
Diameter	17.8 ft	16.8 ft	27.6 ft	27.6 ft	27.6 ft	27.6 ft	32.8 ft
Internal Diameter	15.0 ft	15.0 ft	24.6 ft	24.6 ft	24.6 ft	24.6 ft	29.9 ft
Available Volume	7,740 ft³	9,030 ft³	10,100 ft³	11,260 ft³	18,970 ft³	31,950 ft³	46,610 ft³
Potential Availability *(No Earlier Than)*	-	-	2021	2022	2022	2022	2028



Blk 1B

COTS: Commercial Off-the-[illegible] Universal Stage Adapter CPL: Co-manifested Payload [illegible]

Range of SLS Spacecraft/Payload Types



SLS Payload Accommodations

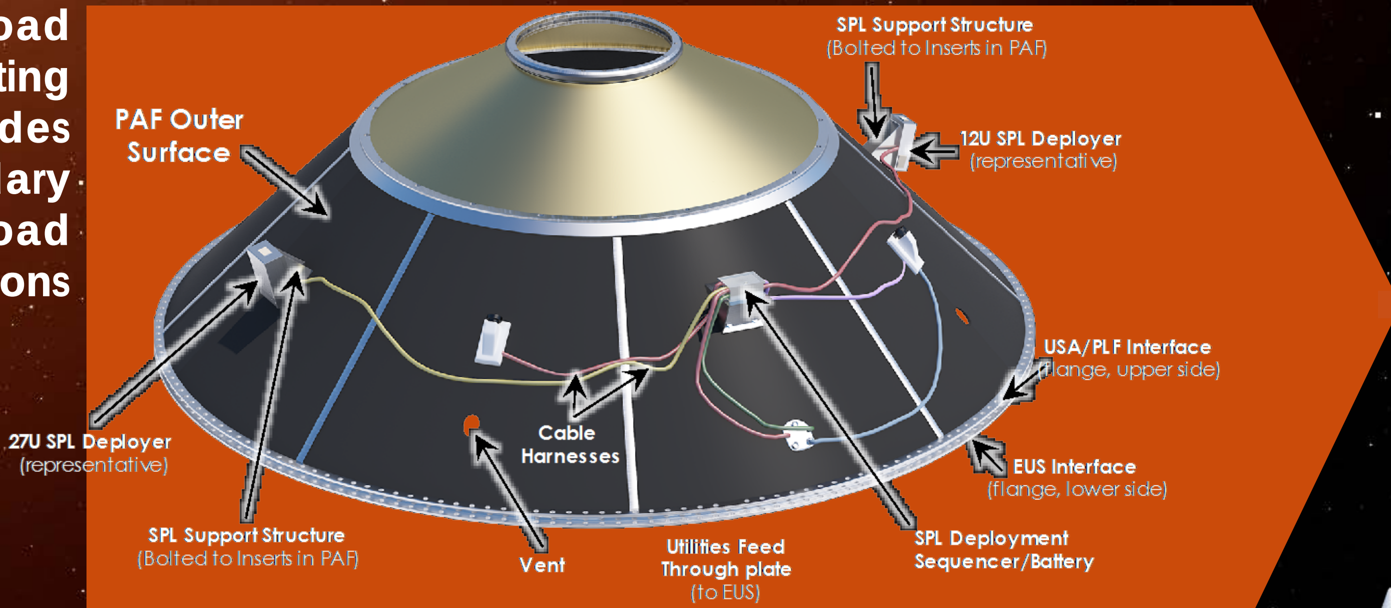
Adapter/Fairing Availability

- Universal Stage Adapter offers opportunity for co-manifested payloads with Orion spacecraft or near-term 8.4-meter lower-height accommodations.
- Universal Stage Adapter accommodations available as soon as 2021
- 8.4- and 10-meter fairings available in the mid- and late-2020s, respectively.

	Science Missions	Orion with short-duration hab module	8m fairing with large aperture telescope	10m fairing w/notional Mars payload
total mission volume = ~	400m3	400m3	1200m3	1800m3

SLS Secondary Payload Capability

SLS Payload Attach Fitting (PAF) provides Secondary Payload accommodations



- Block 1B vehicle offers up to seven 12U to 27U payload locations (or their volume equivalent) on the PAF outer face
- Payloads will be "off" from roll-out through Orion separation and payload deployment
- Payload Deployment System Sequencer; payload deployment will begin with pre-loaded sequence following Orion separation and Upper Stage disposal burn
- Payload requirements captured in a Interface Definition and Requirements Document

One Launch, Multiple Disciplines

The first SLS launch will carry 13 6U smallsats, representing multiple disciplines and partners. The smallsats will be deployed from the Orion Stage Adapter.

Sun

- CuSP (Southwest Research Institute)

Earth

- EQUULEUS (JAXA)
- Skyfire (Lockheed Martin)

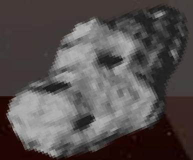
And Beyond

- Biosentinel (NASA)
- ArgoMoon (ESA/ASI)
- Three Centennial Challenge Winners (TBD)

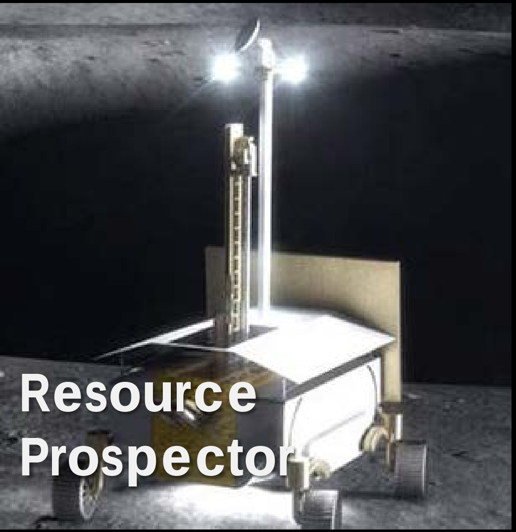
Moon

- Lunar Flashlight (NASA)
- Lunar IceCube (Morehead State University)
- LunaH-Map (Arizona State University)
- Omotenashi (JAXA)

Asteroid

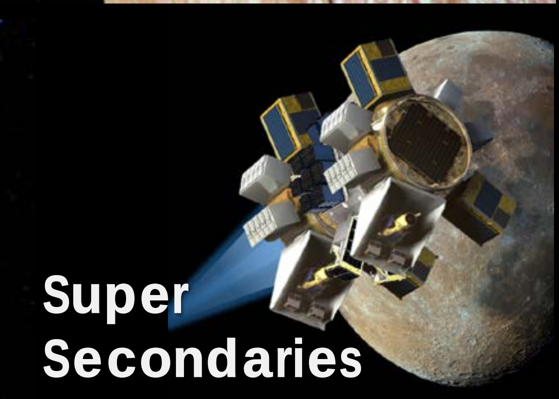


- NEA Scout

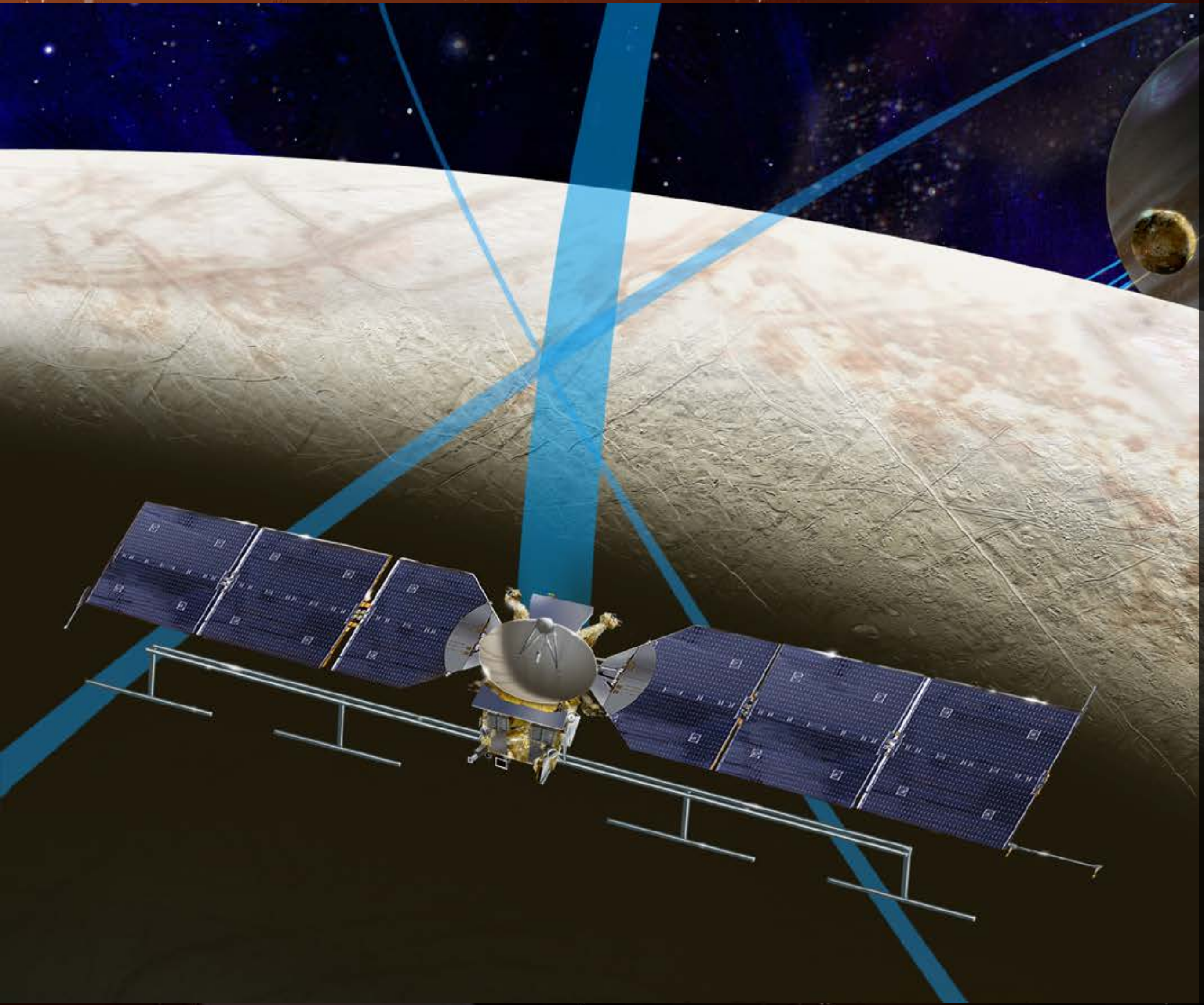


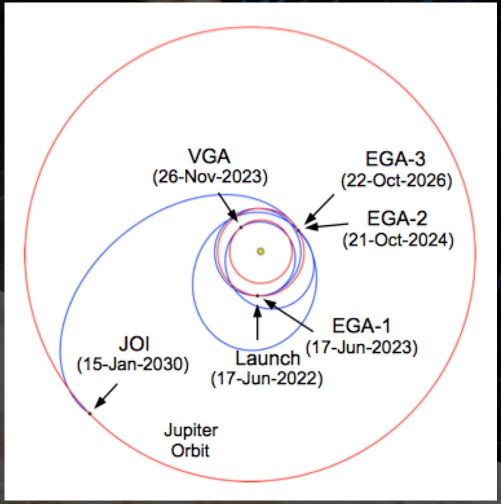
Potential Near Term SLS Missions

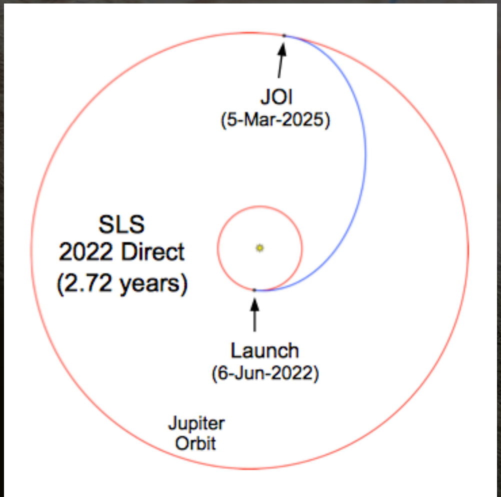
Timeframe: 2021- 2025



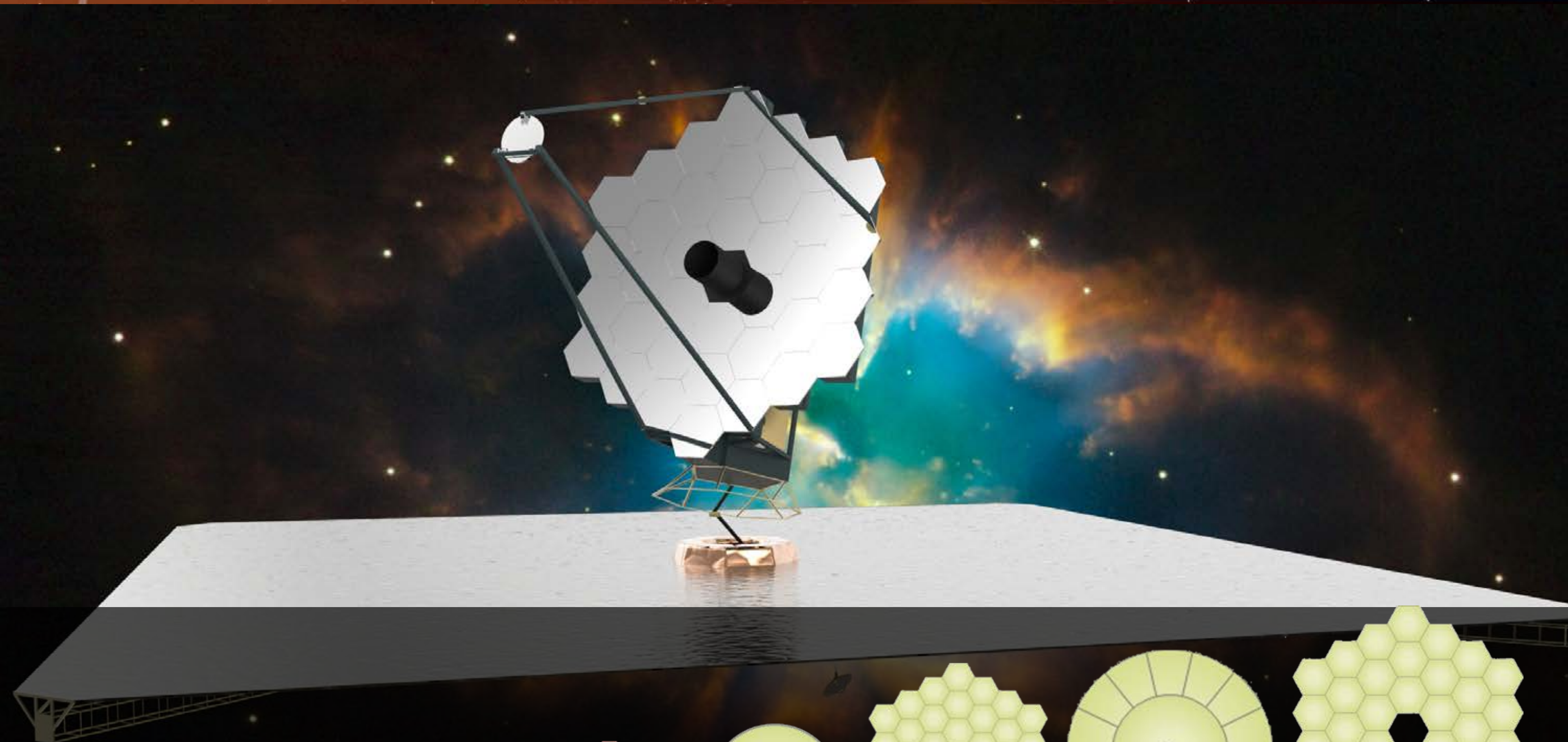
Utilization of SLS Departure Energy

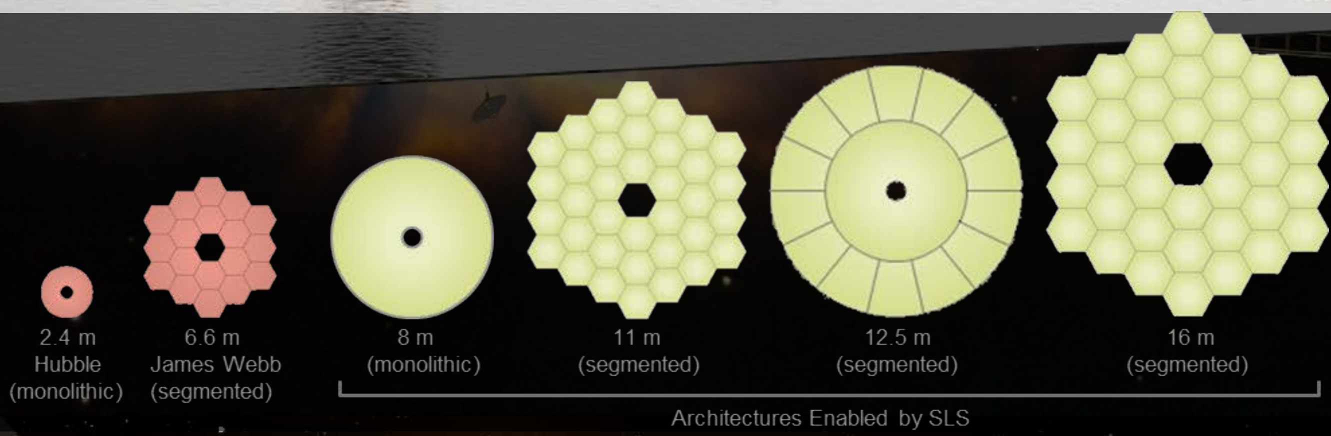




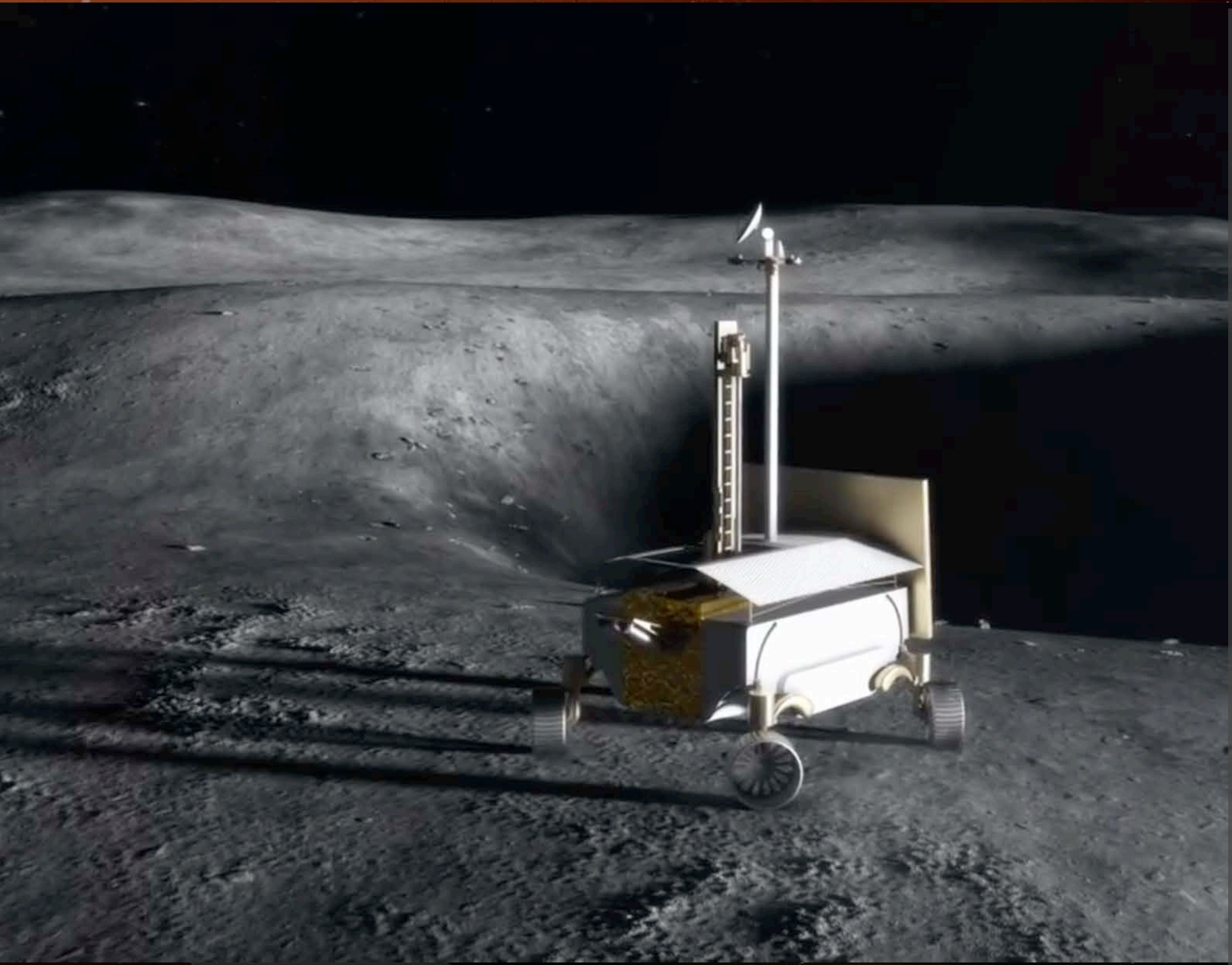


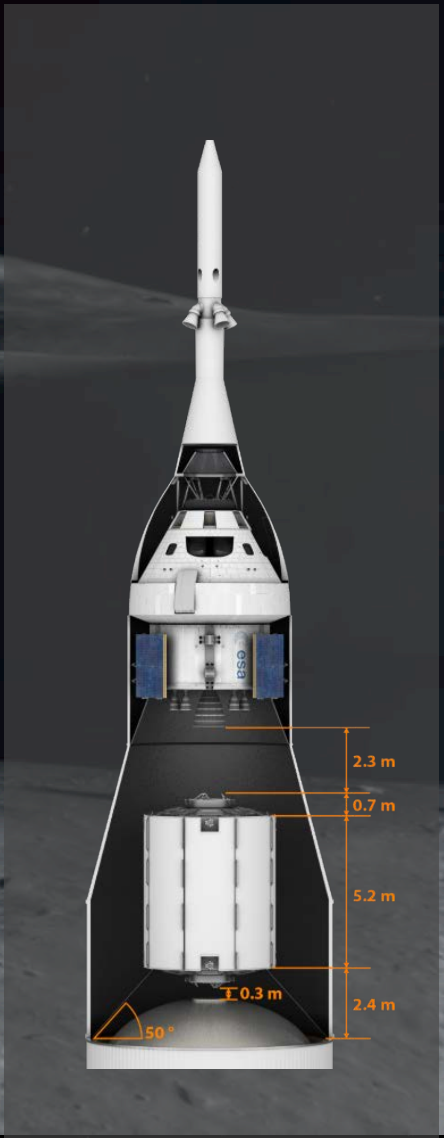
Utilization of SLS Volume





Utilization of SLS Co-Manifest Capabilities





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